LINEAR DUNES AT WILSONS PROMONTORY AND SOUTH-EAST GIPPSLAND, VICTORIA: RELICT LANDFORMS FROM PERIODS OF PAST ARIDITY

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Within the low-lying areas of northern Wilsons Promontory and south-east Gippsland extensive areas of linear dunes are preserved in the modern landscape. The dunes are morphologically similar to the linear dunes that have been described from arid and semi-arid regions of Australia. The trends of the dune crests reflect a predominance of west to north-westerly winds during their time of formation, which is in contrast to the prevalence of south-westerly onshore winds experienced today. These dunes are relict features that developed during the more arid, continental conditions associated with glacial periods. This evidence supports interpretations involving a substantial southerly expansion of the inland dune systems during periods of past aridity.

THIS paper describes the linear dunes and some of the associated landscape features in the northern part of Wilsons Promontory as well as similar dunes from elsewhere in south-east Gippsland, Victoria.

Extensive areas of linear dunes are a major feature of arid and semi-arid areas of Australia (Wasson 1986; Bowler & Magee 1978). These dunes are essentially relict features and were active in arid and semi-arid climatic conditions during glacial periods, such as between 25 000 and 16 000 B.P. when linear dunes were last active (Bowler 1976; Gardner et al. 1987). Some dunes are still active in highly arid areas such as the Simpson Desert (Wasson 1983), and where stabilising vegetation has been cleared (Bowler & Magee 1978). The orientations of Australian continental dunes broadly conforms to a continental scale anti-clockwise whorl (Jennings 1968; Wasson et al. 1988). Sand transport has been towards the east in the southern areas, as in the Mallee, towards the north in the eastern part, as in the Simpson Desert and towards the west in the northern part of the whorl, as in the Great Sandy Desert (Fig. 1).

Restricted areas of similar dunes also occur in temperate regions of Australia that no longer experience an arid climate. Examples include: the 'relict terrestrial dunes' from north-eastern Tasmania (Bowden 1983), the 'old dunes' on King Island (Jennings 1959), the 'extensive areas of linear dunes' on Flinders Island (Sutherland & Kershaw 1971; Kershaw & Sutherland 1972) and the dunes at Cranbourne in Victoria (Bowler 1990). These features are relict forms reflecting the extension of arid conditions into these areas, during glacial periods (Bowden 1983; Bowler & Wasson 1983). The location of south-east Gippsland, on the periphery of the Australian continental region is in a location likely to have been greatly affected by climatic oscillations during the Quaternary.

We will first describe the dunes from the Wilsons Promontory area, followed by an extension of these features further north in south-east Gippsland. We will conclude with a discussion of the palaeo-environmental implications for this region. Fig. 2 shows a regional map of the area considered in this paper.

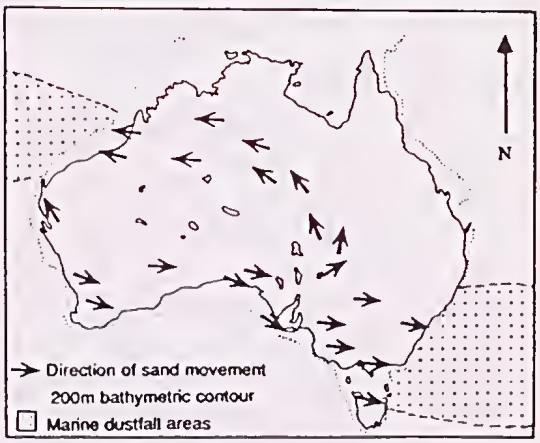

Fig. 1. Australian Pleistocene dune map, showing the areas of terrestrial dune activity and the continent scale anticlockwise 'whorl' pattern of dune trends. (Modified after Bowler 1976; Wasson 1988.)

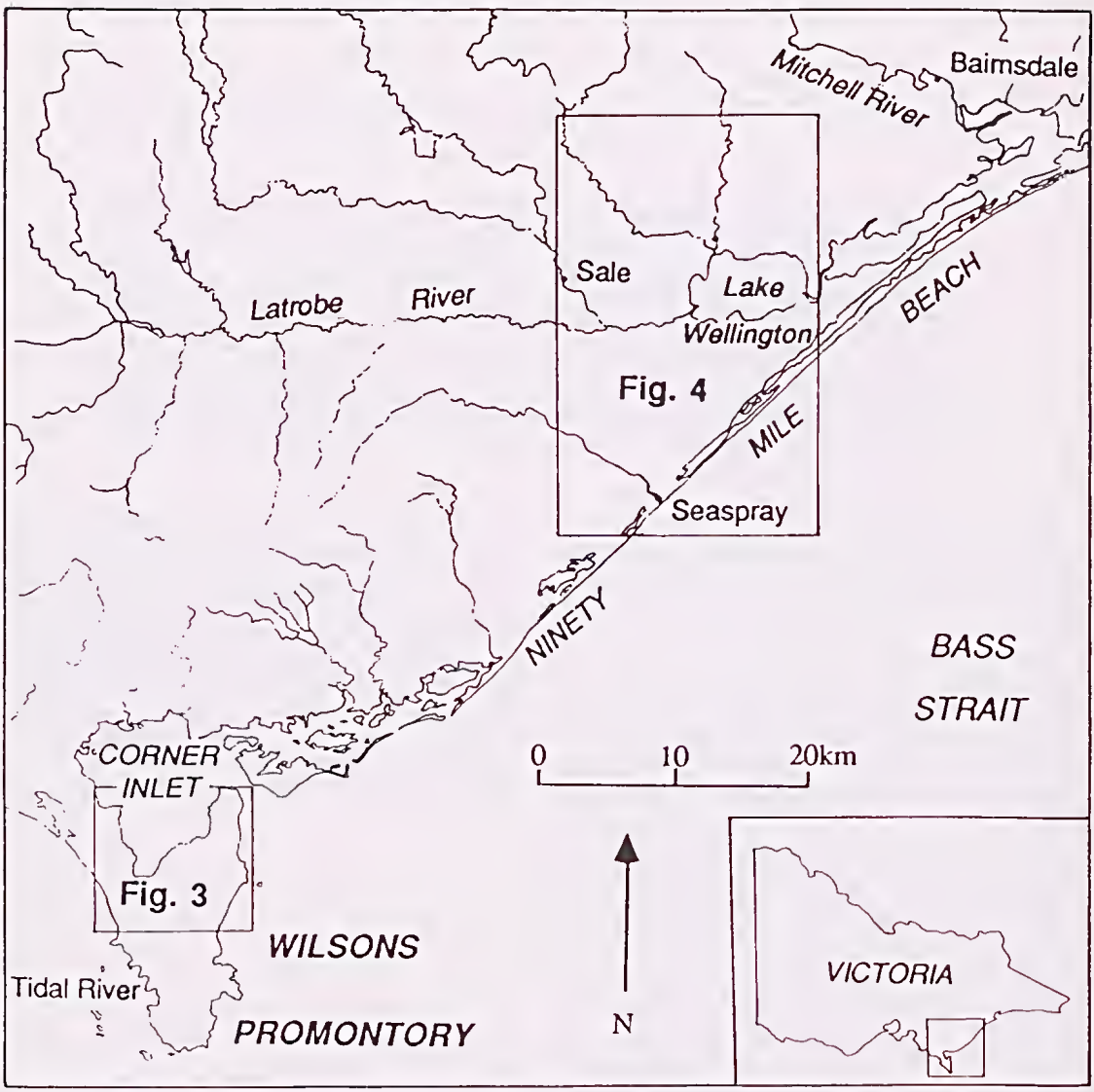

Fig. 2. Regional map of south-east Gippsland showing the areas considered in this paper.

LINEAR DUNES OF NORTHERN WILSONS PROMONTORY

Landscape setting

Wilsons Promontory, the most southerly point of the Australian mainland, lies approximately 230 km southeast of Melbourne. It presently experiences a temperate maritime climate. The annual temperature ranges from 0–38°C, with an average of 14°C in summer and 8°C in winter. Annual rainfall has a slight winter maximum and ranges from 100 cm on the west and south coast to at least 150 cm at higher altitudes. West-south-westerly on-shore winds presently prevail, with occasional strong winds from the east and southeast.

Wilsons Promontory consists of a series of granitic highland ridges with adjacent low-lying areas of Cenozoic sediments. The coastal lowlands mostly consist of swampy plains, such as along the southern margins of Corner Inlet and inland of Five Mile Beach, and of dune fields such as on the Yanakie Isthmus. Fig. 3 shows the main geomorphic units of northern Wilsons Promontory.

Weathering of the granites, since their emplacement in the Late Devonian, led to the development of deep weathering profiles by the Mesozoic. Since the mid-Cretaceous, stripping of the deeply weathered material has been greater than the continued weathering, resulting in the present geomorphic features of the granite areas (Hill 1992). The landscape features of the granite areas of Wilsons Promontory are featured in Hill (1992, 1994, in press), Hill & Joyce (1995) and Hill et al. (in press) and will not be discussed in detail here.

Low angle slopes of colluvium and alluvium extend from the granitic highlands onto the coastal lowlands. These mainly consist of materials such as quartz sand and kaolin-group clay minerals derived from the weathering of the granites in the highlands. Tuddenham (1970) considers the possibility that these deposits originated during slope instability associated with cold (periglacial?) conditions during glacial maxima. Whilst periglacial conditions may have extended to the higher peaks of the region during glacial periods, no conclusive evidence has been found to support this suggestion. Hill (1992) found evidence for several periods of slope instability up to the present time and concluded that the extensive development of these deposits is mainly due to a combination of factors: (i) the steep and dissected terrain; (ii) an abundance of weathered material with reduced bulk density and shear strength; (iii) a tendency for the area to experience periods of torrential rain; and (iv) the removal of the vegetation cover by forest fires.

Calcareous and siliceous sands

Calcareous and siliceous sands of marine and aeolian origins occur along most coastal margins of northern Wilsons Promontory. Beaches to the west, such as Waratah Bay, have modern deposition of calcareous sands derived from submarine ridges of calcareous sediment. Beaches on the east coast, such as within Corner Inlet, are characterised by siliceous sands transported from the east. Localised areas of siliceous sand along the west coast represent material deposited before the development of the Yanakie Isthmus, which became a barrier to the movement of further siliceous sands from the east. Aeolian and marine reworking of many of these siliceous sands, formed extensive flat-lying sand sheets, such as that west of the Vereker Ranges (Fig. 3).

Sequences of beach ridges on the east coast of Wilsons Promontory represent progradation of the coastline since the post-glacial marine transgression, 6500–4000 B.P. (Tuddenham 1970; Thom & Roy 1985). The most extensive development of beach ridges occurs in the Entrance Point area, where Tuddenham (1970) made a detailed study of the more than 80 ridges that have filled the original embayment. The granite bluff backing the ridges represents a coastline predating progradation.

The calcareous sands of the west coast of Wilsons Promontory form beaches and aeolian calcarenites. Calcareous dunes are parabolic, with dune axes trending to the west-south-west (Fig. 3). This trend conforms to the present west-south-westerly on-shore wind resultant. Recent movement of these sands has progressed westwards across the width of the southern part of Yanakie Isthmus and into Corner Inlet (Fig. 3).

Linear dunes

Narrow-crested, east-west trending linear dunes extend across much of the coastal lowlands of northern Wilsons Promontory. Early work in this area by Tuddenham (1970) and Wallis (1981, 1987) made brief reference to these dunes. Oyston (1988) recognised the significance of similar dunes in the northern Yanakie Isthmus. Hill (1992) later found these dunes to be much more extensive than was previously thought, with the recognition of similar features on the coastal lowlands adjacent to Corner Inlet and Three Mile Beach (Fig. 3). Dunes do not occur on the extensive coastal plain backing Five Mile Beach, probably due to its position on the leeward side of the Vereker Range.

The dunes are best recognised on aerial photographs. They appear as elongate rises, vegetated with a shrubby woodland surrounded by lower poorly drained swales characterised by a swampy heathland community. The dunes originate on the plains and extend up the lower slopes of adjacent granite hills, usually terminating below 20 m above present sea level. They consist of well-sorted and rounded, fine to medium grained quartzose sands. Dune crests are commonly less than 1 km long and spaced between 200 and 500 m apart. They are characterised by a well-developed sandy podzolic soil.

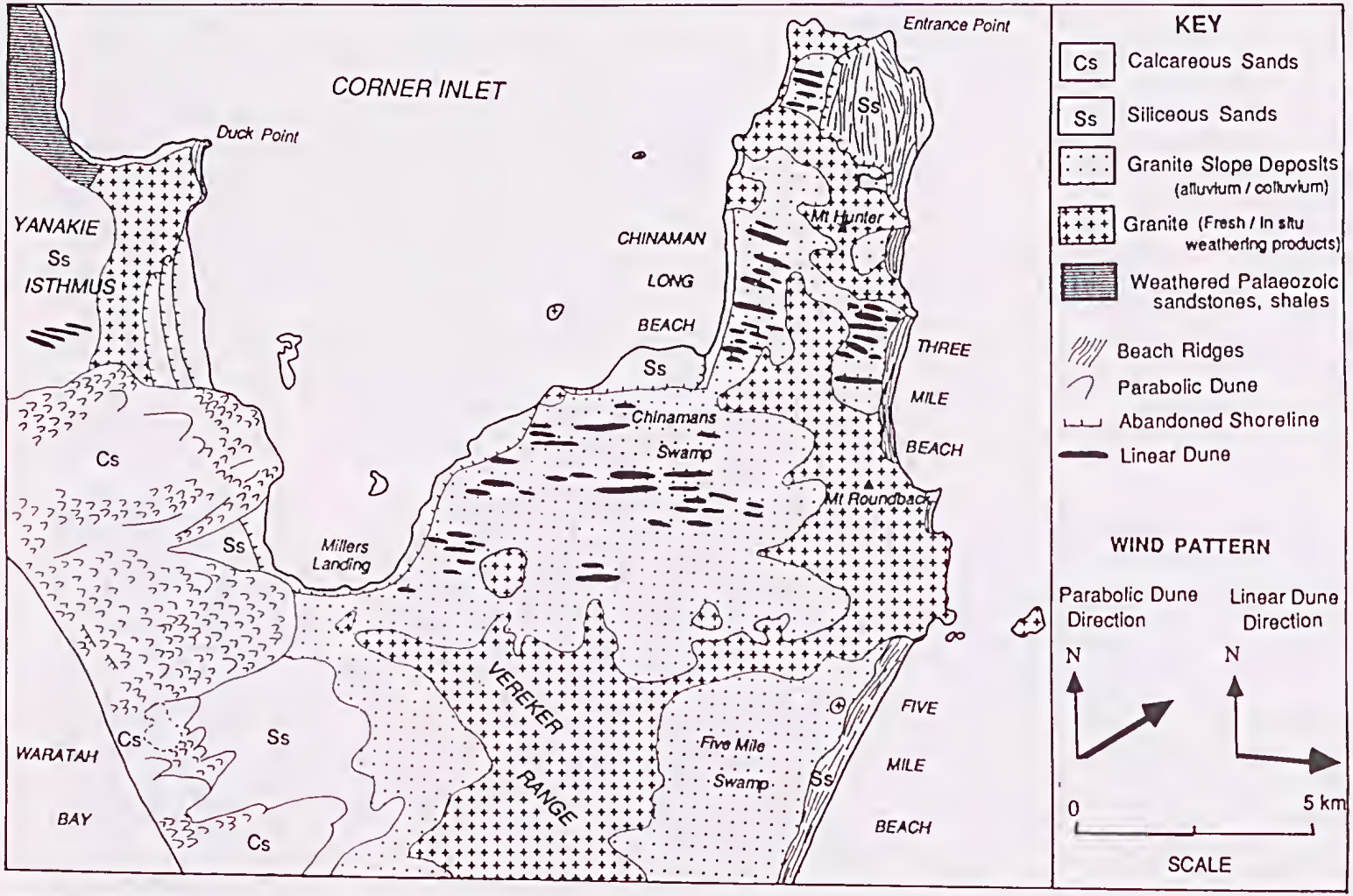

Fig. 3. Geomorphic map of northern Wilsons Promontory (after Hill 1992), showing the main landscape features and the resultant trends of the recent dunes in comparison to the linear dunes.

Oyston (1988) suggested that the source of the sands in the dunes was the marginal marine siliceous sands found to underlie the Yanakie Isthmus area. The ultimate source, however, would be the granites of the Wilsons Promontory batholith with possible contributions also from the weathered Palaeozoic sandstones intruded by the batholith. Small amounts of tourmaline, a common accessory mineral in the Wilsons Promontory granites (Wallis 1981, 1988), support the ultimate granitic source hypothesis. The marginal marine siliceous sand source suggested by Oyston (1988) would be the proximate source of sand derived from more recent erosion. The granite slope deposits would also contribute siliceous material that is then reworked. Aeolian and marginal marine reworking of the slope deposits have removed the clay fraction, leaving quartz sand to be moved across the surface of the coastal plains developing the linear forms.

The alignment of the linear dune trends is between east–west and northwest to southeast, reflecting a mean west-northwesterly wind resultant (Fig. 3). This is in contrast to the modern onshore, west-southwesterly resultant that is reflected in the Recent calcareous parabolic dunes. The high degree of podzol soil development on the dunes, compared to the poor development of profiles on the Holocene calcareous dunes suggests that the linear dunes are pre-Holocene. Other features indicative of antiquity include: degraded rounded crests, well-developed vegetation communities, truncation by post-glacial shoreline features and their stratigraphic position underlying transgressive calcareous dunes in the northern Yanakie Isthmus area.

DUNES AND SAND SHEETS IN SOUTH-EAST GIPPSLAND

The environment represented by the Wilsons Promontory dunes finds additional expression in linear dunes further north near Seaspray in South Gippsland (Fig. 4). Here a series of west to east trending sand ridges occur between the uplands of the South Gippsland ranges and the coastal sand barriers. Previously interpreted as relict coastal features (Jenkins 1968), a significant percentage of the inland dunes are almost certainly of terrestrial origin.

High level sand ridges mapped by Jenkins (1968: plate 3) extend over a large area of South Gippsland. They occur from Monkey Creek in the south towards Longford in the north. North of Lake Wellington they extend from Perry Bridge in the south to Lindenow South near the Mitchell River in the northeast.

The distribution of crestal ridge trends (Jenkins 1968: fig. 66) varies from an E–W direction in the north to WNW–ESE in the south. Near Seaspray, the dune trends intersect the present coastline at an angle of 55–60°. South of Lake Wellington, trends are mainly E–W remaining closely parallel to the shoreline. North of Lake Wellington, dunes on the eastern (downwind) side of the Perry River trend mainly between 70–80°.

Jenkins, sensing the possibility of a terrestrial origin, used several lines of argument to associate the dunes with a coastal marine rather than terrestrial origin. These arguments are summarised below.

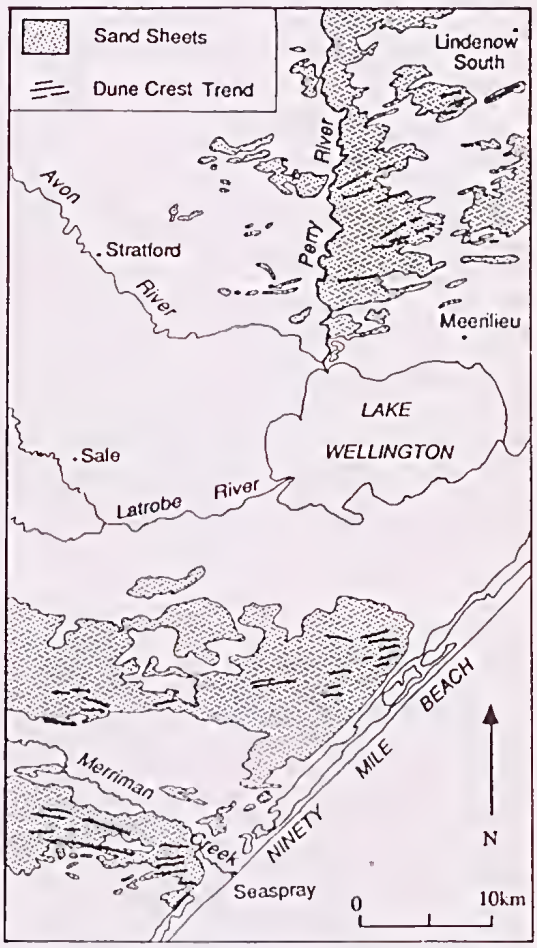

Fig. 4. Map of the Seaspray to Lindenow South area, showing dunes and sand sheets (after Jenkins 1968).

Marine hypothesis

1. Different fields show somewhat different trends. Those south of Merriman Creek have a more southeasterly trend than those further north as along the Princes Highway between Stratford and Bairnsdale. This was taken by Jenkins to be consistent with *the direction and successive position of the former coastline.*

However, it is only in the north that dune trends parallel those of the shoreline where both trend approximately east–west. In the south, near Seaspray, dune and coastline trends differ by up to 60°. The argument based on parallel accordance does not hold.

2. Structures in the lower parts of the ridges are horizontal or dipping at low angles more consistent with beach or beach ridge deposits. However, sub-horizontal, low angle conformable deposition is also characteristic of sand sheets and low sand ridges where avalanche bedding does not develop. The upper parts of the ridges and crestal trends are certainly wind controlled.

3. Sediment in the lower sections is too coarse to be wind deposited with *areally extensive beds of fine gravel being common throughout* (Jenkins 1968: 82). This reference to an example described from Meerlieu lies closest to the undeniably marine features of the Lake Wellington-Victoria complex.

While this example is almost certainly representative of marine origin in this area, our discussion concerns the extensive dune and sand sheet features that extend for some 30 km north of Meerilieu. Within the area where dunes are found extensively on gravel deposits, basal horizons of gravel representing parent materials will be found in the core of ridges. A problem remains in differentiating between those ridges of genuine marine origins from those which bear no genetic relationship to shorelines.

Terrestrial hypothesis

1. The dunes discussed here, with those defined from Wilsons Promontory, follow the same regional trends of glacial age dunes throughout southeastern Australia. Even the divergence in trends from slightly north of east in the Stratford-Bairnsdale area to south of east near Seaspray is precisely what might be expected from consideration of effects of local topography.

2. The discordance between dune and coastal trends near Seaspray rules out a marine origin for the dunefield immediately south and north of Merriman Creek.

3. The extensive sand sheets north of Lake Wellington are similar to others of known terrestrial origin. They are limited almost exclusively to the eastern or downwind side of the Perry River, suggesting an obvious sand source. This is precisely the relationship between stream and glacial age sandsheets known from other parts of southeastern Australia, as in the Shoalhaven River on the southern Tablelands at >700 m elevation where no relationship to Quaternary sea levels can be entertained.

DISCUSSION

Palaeo-environmental interpretation

The dominance of westerly to west-northwesterly winds during the formation of the linear dunes is similar to the wind patterns related to linear dune formation along the southern extent of the Australian continental dune field. The morphology of the dunes is also similar to the arid climate linear dunes, such as those of the Mallee region of northern Victoria (Bowler & Magee 1978). This suggests that Wilsons Promontory and south-east Gippsland once experienced a similar arid continental climate. Such conditions would have affected this area during glacial periods, such as the Last Glacial Maximum approximately 20 000 years B.P.

During the glacial periods with oceanic water locked in expanded polar ice caps, sea levels were considerably lower. The last glacial period resulted in sea levels to 150m lower than present (Jennings 1971; Chappell & Shackleton 1986). Most of the continental shelf was exposed: an extensive continental plain separated the Australian mainland and Tasmania (Orchiston 1979, 1984). Wilsons Promontory and south-east Gippsland would have then been over one hundred kilometers inland (Fig. 5). The region would have experienced a westerly continental wind in contrast to the south-westerly, on shore winds of today. At this stage the climate was also drier and winds were stronger (Bowler 1976; Bowler & Wasson 1983). The Bassian continental plain removed the moisture source for winds that now derive moisture from the waters of Bass Strait. Cooler sea surface temperatures during the glacial periods would also lower oceanic evaporation further reducing the moisture content of the winds. Such conditions, associated with colder winters, would lead to a significant reduction in the vegetation cover, enhancing deflation of the siliceous sands. Similar dunes almost certainly extended over the areas now submerged by the post-glacial marine transgression.

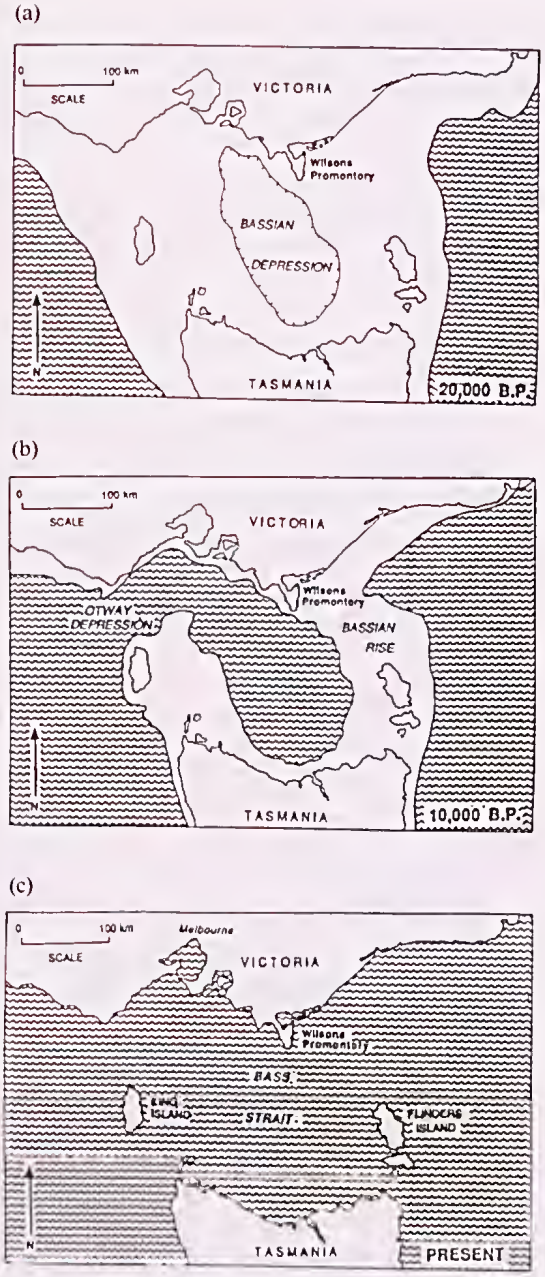

Fig. 5. Palaeogeographic reconstructions of the Wilsons Promontory region at 20 000 years B.P. (a), 10 000 years B.P. (b), and present day (c).

Although strong presumptive evidenee exists for reactivation of dunes and sand sheets during the last glacial maximum (Bowden 1983; Sprigg 1979; Wasson 1986), the formation of the systems deseribed here may well predate that interval. The presenee of strongly developed podzolic soils, such as on the dunes near Merriman Creek and at northern Wilsons Promontory, provides evidenee of antiquity sinee dune stabilization. However, lack of data on actual rates of pedogenie development in this region prevents any accurate age definition. While remobilization during the last glacial maximum is to bc expected, the history of these features almost eertainly involves a much longer period.

A palaeo-geographical reconstruction of events since the last glacial maximum, approximately 20 000 years B.P., demonstrates suecessive changes in post-glacial shorelines (Fig. 5). This sea-level rise set the scene for modern coastal wind regimes and the present phase of ealcareous sedimentation west of Wilsons Promontory. The associatcd increase in rainfall, decrease in the frequeney of strong winds and an inerease in vegetation cover, all assisted stabilisation of the linear dunes and subsequent podzolic soil development.

CONCLUSION

The evidcnee advanced here re-inforces previous interpretations involving a substantial southerly expansion of the inland dune systems during periods of past aridity. Seen at the continental scale, thc loeation and orientation of the Gippsland and Wilsons Promontory dunes represent a substantial southeasterly extension of the inland systems.

A combination of increased aridity, lower temperatures, and increased windiness, greatly reduced the vegetation cover compared with that of today's and favoured greatcr aeolian activity in south-east Gippsland. Thesc conditions pcrmitted substantial modifieation of the landseape, including formation of linear dunes trending parallel to the predominantly west to west-northwesterly continental wind regime.

Sinee this timc the sea has transgressed to its present position. Therc has been a decrcasc in windiness and an increase in rainfall and vegetation covcr. Carbonate sedimentation replaced siliceous sedimentation along the west coast of Wilsons Promontory. Onshore south-westerly winds have since been rcsponsible for acolian reworking.

Thc evidence of continental aridity providcd by these featurcs has profound significance for understanding environmental evolution throughout southeastern Australia. The relativcly high rainfall eonditions that characterise these areas today appear to be quite unrepresentative of conditions that prevailed within the geologically reeent past.

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